PROPULSION DIRECTORATE

Monthly Accomplishment Report
August 2004

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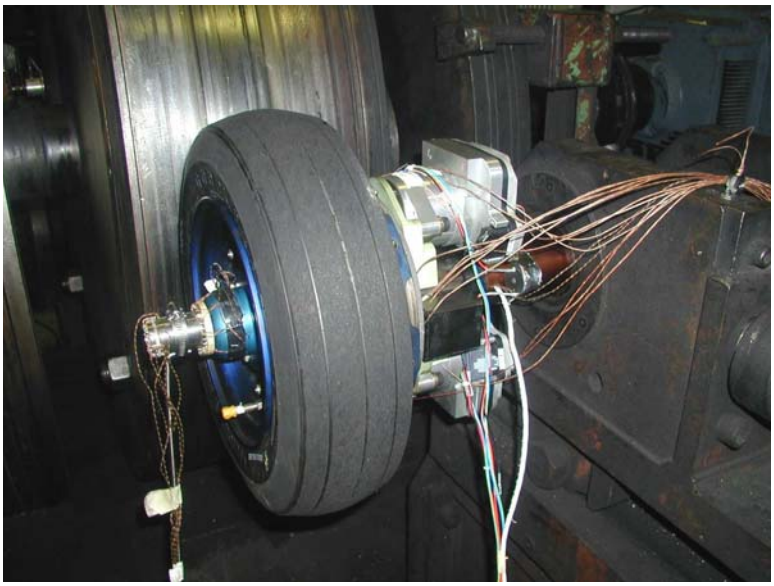
NEW BEARING RIGS SUPPORT DEVELOPMENT OF ADVANCED TURBINE ENGINES: A team of Propulsion Directorate researchers conceived and built two unique research facilities to support the development of revolutionary bearing technologies. These facilities, which have completed qualification testing and are now fully operational, will provide critical information for the development and qualification of Air Force Versatile Affordable Advanced Turbine Engines (VAATE) Program bearing and lubrication systems. The Bearing Life Assessment Facility provides the highest fidelity bearing life validation capability in the US for subscale turbine engine mechanical systems by generating realistic load, speed, and temperature conditions simultaneously over an extended period of operation. This facility provides unprecedented capabilities to evaluate bearing materials, lubricants, and diagnostics for the reliability that man-rated systems require. The High Mach Engine Bearing Development Facility is the first of its kind to operate at the bearing system conditions for a Mach 2.2 man-rated turbine engine necessary for Long Range Strike (LRS) applications. With this capability, bearing technology can now be demonstrated without risking damage to costly test engine assets. These two new research facilities enable the development of crucial bearing systems for growth LRS applications at greatly reduced risk, and therefore will lead to significant savings to the Air Force. This project was named the FY04 3rd Quarter Propulsion Directorate In-House Project of the Quarter, and the following individuals were recognized for their contributions to this effort: Mr. Garry Givan, Mr. Kevin Thompson, Dr. Jeff Brown, Dr. Nelson Forster, Mr. Vaughn Svendsen, 1Lt Daniel Doak, 2Lt Steve Hamamgian, and Mr. Dave Gerardi.* (Dr. R. Wright, AFRL/PRTM, (937) 255-5568)

The team above was honored as the FY04 3rd Quarter Propulsion Directorate In-House Project of the Quarter. Pictured (from L to R) are: Dr. Jeff Brown, Mr. Dave Gerardi, Dr. Nelson Forster, Mr. Garry Givan, 1Lt Dan Doak, 2Lt Steve Hamamgian, and Mr. Kevin Thompson. (Not pictured: Mr. Vaughn Svendsen)

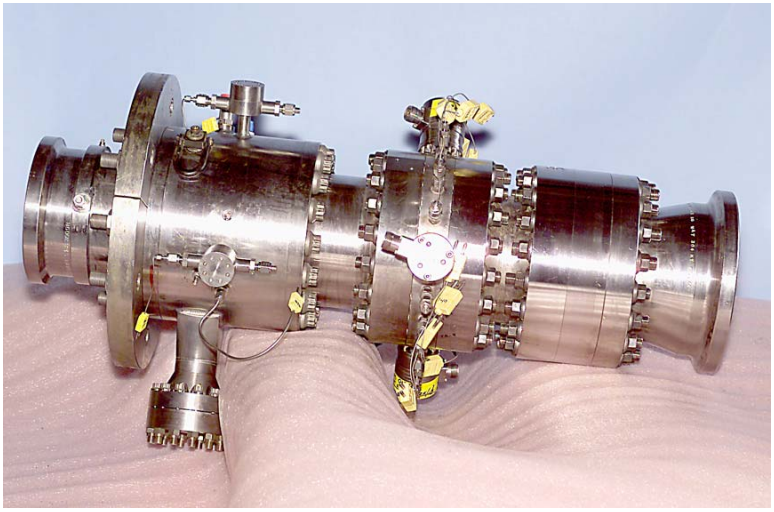
* Mr. Gerardi is an on-site contractor with UES, Inc.

PROTOTYPE UAV BRAKE SYSTEM DEMONSTRATED: The Low Cost Electric Brake System (LCEB) Program successfully demonstrated its first prototype brake system on 19 August 2004. The LCEB program is a Dual-Use Science and Technology (DUS&T) Program managed by the Propulsion Directorate with industrial partners Aircraft Braking Systems Corporation (ABSC) and Delphi Automotive. The demonstration test occurred at ABSC's facility in Akron, Ohio. The test simulated the braking energy required to stop an approximately 4,500 pound vehicle from a speed of 140 mph in 1500 feet. This represented a deceleration of about 14 ft/s^2, which is very close to the theoretical maximum for this particular tire and vehicle combination. Subsequent testing has successfully demonstrated an emergency stop from 193 mph over a greater stopping distance. The test fully met the objectives, which included anti-skid and repeated thermal cycling. It is noteworthy that the brake system being developed in this program has been selected by General Atomics to equip future variants of their Predator series of airframes. Funding is presently being sought to permit a full flight test series and the construction of adequate spares. (Mr. B. Jordan, AFRL/PRPE, (937) 255-9394)



The Low Cost Electric Brake System recently demonstrated its first prototype brake system

INTEGRATED POWERHEAD DEMO READY FOR FULL ENGINE TESTS: The Propulsion Directorate recently completed testing of the Liquid Hydrogen (LH2) Preburner for the Integrated Powerhead Demonstration (IPD) Program. This testing successfully validated the design elements of the LH2 preburner, and it marked the completion of all component testing for the IPD project. With component testing complete, the IPD project is now ready for full integrated engine testing, which is currently scheduled to commence in January 2005. The IPD Program addresses the DoD and NASA need to operate a highly reliable and long life rocket engine system with significantly reduced operational costs. Through the utilization of a full flow staged combustion cycle, the



The Integrated Powerhead Demonstration program's liquid hydrogen preburner

IPD engine can achieve life and reliability 10 times greater than the Space Shuttle Main Engine. The technology embodied in the IPD engine components can be used for both long life reusable systems and highly reliable low cost expendable rocket engines. (Mr. S. Hanna (661) 275-6021)

Testing of the Integrated Powerhead Demonstration program's liquid hydrogen preburner

ANOTHER SUCCESSFUL TURBINE ENGINE TECHNOLOGY SYMPOSIUM: The Turbine Engine Division of the Propulsion Directorate hosted the 2004 Turbine Engine Technology Symposium (TETS) from 30 August to 2 September 2004 at the Dayton Convention Center in Dayton, Ohio. The TETS is the only forum where the US turbine engine community gathers to review and discuss the latest technology advances achieved through the Integrated High Performance Turbine Engine Technology (IHPTET) and, more recently, the Versatile Affordable Advanced Turbine Engines (VAATE) Programs. This year's symposium, which had the theme "Expanding the Boundaries," was well attended, with more than 650 participants from government, industry, and academia. Gen Gregory S. Martin, Commander of the Air Force Materiel Command, gave an inspirational keynote address, receiving a standing ovation, and Mr. Michael W. Melvill, Vice President/General Manager and Test Pilot at Scaled Composites LLC, was the speaker at the symposium banquet. The banquet was preceded by a ground

demonstration of a Pulsed Detonation Engine (PDE) powered Long EZ. The PDE is being developed by AFRL/PRT, with Mr. Melvill acting as the test pilot. The first flight of the PDE powered Long EZ is expected to occur later this fall at Wright-Patterson AFB. Mr. Melvill rocketed to notoriety when he became the first private pilot to be presented with Astronaut Wings after he piloted SpaceShipOne to an altitude of 328,491 feet on 21 June 2004. The symposium was replete with senior level managers representing the engine manufacturers, weapon system contractors, and government organizations that provided presentations regarding the recent successes and the pending completion of the IHPTET Program in 2005, plans for achieving the VAATE Program goals by 2017, and the affects provided by these successful demonstrations and technology transition to provide future systems with transformational capabilities. (Mr. D. Jay, AFRL/PRTP, (937) 255-7510)

Gen Gregory S. Martin (left), AFMC/CC, gave the keynote address for the 2004 Turbine Engine Technology Symposium. Mr. Michael W. Melvill (right), Vice President/General Manager and Test Pilot at Scaled Composites LLC, was the speaker at the 2004 Turbine Engine Technology Symposium banquet. He is shown here receiving his Astronaut Wings.

TESTING SEEKS TO REDUCE EMISSIONS FROM FUTURE AIRCRAFT: The Propulsion Directorate was part of a team that recently obtained the most extensive set of gaseous and particulate emissions data from an in-service commercial aircraft jet engine. This collaborative effort, dubbed the Aircraft Particle Emissions eXperiment (APEX) project, has the goal of characterizing gaseous and particulate emissions from a NASA DC-8 aircraft and its CFM-56 engines. The characterization of these emissions will aid in advancing the understanding of particle emissions from commercial aircraft engines. In recent years, fine particulate emissions from aircraft have become increasingly important because they are suspected of contributing to global climate change and lowering local air quality. The international aviation community is interested in the potential effects of these emissions and has consequently specified measurement technology and identified possible limitations and controls. Regulatory agencies have likewise begun to examine methods for measuring particle emissions from aircraft gas turbine engines.

The various participants in the APEX project have undertaken numerous activities related to the emissions problem, such as: (1) examining the effect of engine thrust on particulate emissions; (2) simulating emissions at airports; and (3) studying fuel effects on particulate emissions by varying fuel composition. Researchers are currently analyzing the data and planning a special meeting in November 2004 to discuss the results and reach preliminary conclusions. The participants in the APEX project include NASA, the Environmental Protection Agency (EPA), the Federal Aviation Administration (FAA), other DoD organizations, and numerous industrial and academic partners. (Mr. E. Corporan, AFRL/PRTG, (937) 255-2008)

Want more information?

- A NASA Press Release on the APEX program is available at the following address: http://www.grc.nasa.gov/WWW/PAO/pressrel/2004/04-058.html

The NASA DC-8 aircraft used for studying jet engine gaseous and particulate emissions

Testing emissions from a CFM-56 engine

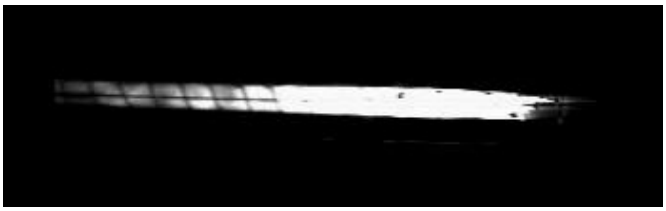
IMPROVED ENVIRONMENTAL CONTROL UNITS FIELD TESTED: The Propulsion Directorate's contribution to the recent 2004 TEAM PATRIOT exercise at Fort Drum, New York, was an improved Environmental Control Unit (ECU) (i.e., tent cooler). For this year's exercise, PR provided an advanced prototype ECU, including several improvements from the prototype used at last year's TEAM PATRIOT exercise. Currently fielded ECUs, also known as Field Deployable ECUs or FDECUs, are notorious for their excessive weight, bulk, maintenance problems, and acoustic signatures. For this latest environmentally friendly prototype, weight was reduced by about 30% compared to the current FDECU, and numerous improvements were made in reliability and maintainability. The ECU performed exceptionally well, and the warfighters were impressed with its performance. This improved ECU resulted from a Cooperative Research and Development Agreement (CRADA) between AFRL and Mainstream Engineering Corporation at no cost to the DoD. The success of this program is the result of significant coordination with many Air Force users. (Mr. J. Gottschlich, AFRL/PRPE, (937) 255-5734)

A field deployable Environmental Control Unit (ECU) (PR's Maj Mona Wheeler is pictured)

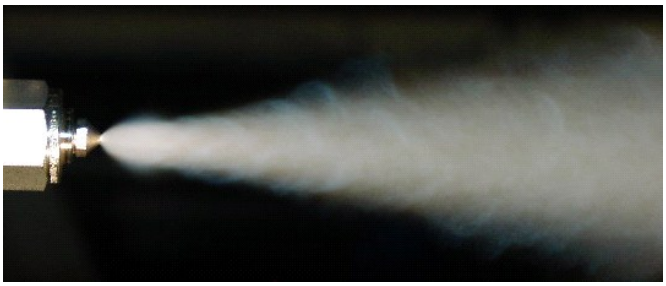
Dr. Lawrence G. Scanlon, Jr. was recently selected to receive the Exemplary Civilian Service Award

BATTERY RESEARCHER HONORED: The Propulsion Directorate's Dr. Lawrence G. Scanlon, Jr. was recently selected to receive the Exemplary Civilian Service Award. Dr. Scanlon was recognized for leading a team that successfully developed a solid-state lithium battery electrolyte for rechargeable batteries. He skillfully defined and executed a research plan that incorporated diverse research efforts from Argonne National Laboratory, Wright State University, and AFRL to solve the critical issues to successfully develop the new electrolyte. The results of his work were truly spectacular and provided a

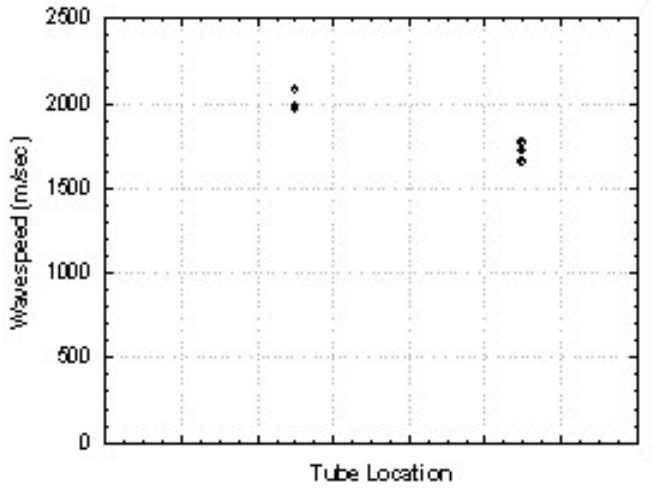
breakthrough material that will define future energy storage devices for space, air, and ground for both military and commercial applications. His demonstration of a robust highly capable solid-state battery presents many opportunities to integrate power systems into vehicular structures or make them conformal to available areas with total design flexibility. Dr. Scanlon was also the recipient of PR's prestigious S. D. Heron Award for outstanding basic research in 2003. (Mr. J. Nairus, AFRL/PRPS, (937) 255-5948)



High speed imaging of deflagration to detonation transition with supercritical fuel injection



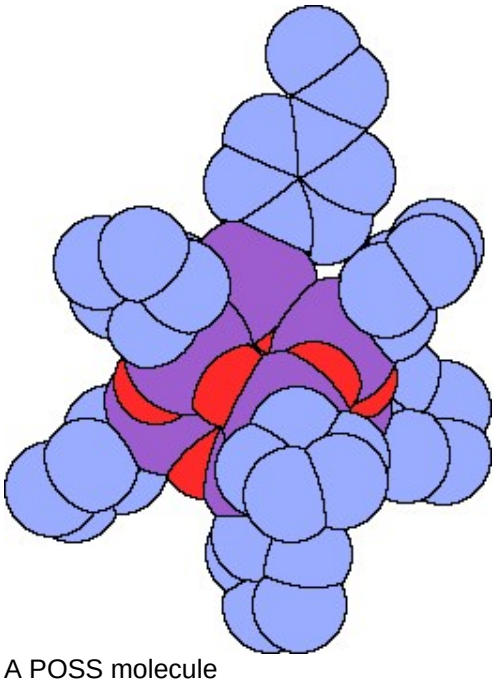
A supercritical fuel injection nozzle



Detonation wavespeed vs. tube location indicating successful Mach 5-6 detonation speeds for JP-8 in air

RESEARCHERS SUCCESSFULLY DETONATE JP-8 IN AIR: A supercritical fuel injection system designed, built, and tested in-house has enabled Propulsion Directorate researchers to detonate JP-8 in air. The pulsed detonation engine (PDE) supercritical fuel injection system, developed as part of Capt Colin Tucker's AFIT PhD thesis research in collaboration with PR, has enabled researchers to detonate a wide variety of liquid fuels with a relatively simple, steady flow injection system. The supercritical injection system delivers fuel without coking and enables detonation of mixtures that were previously not detonable in air. JP-8 had previously been detonated, but only through the use of complicated injection schemes. The detonation of JP-8 in air with the supercritical PDE injection system is particularly noteworthy because low volatility JP-8 fuel was originally developed in order to reduce the risk of fuel system explosion. The ability to successfully detonate JP-8 in air is significant because it enables PDEs to operate using the same fuels as current Air Force propulsion systems. The development of this technology will increase performance of advanced pulsed detonation propulsion systems while reducing the weight and cost. (Dr. F. Schauer and Capt C. Tucker, AFRL/PRTC, (937) 255-6462)

PATENT ISSUED FOR MODIFICATION OF POSS MOLECULES: US Patent #6,770,724, titled "Altering of POSS Rings," was issued to the Air Force on 3 August 2004. The inventors of this patent are Dr. Joseph D. Lichtenhan (Hybrid Plastics), Dr. Timothy S. Haddad (Propulsion



A POSS molecule

Directorate),[†] and Prof. Frank J. Feher[‡] and Dr. Daravong Soulivong (University of California-Irvine). This invention discloses methods that enable the selective manipulation of the silicon-oxygen frameworks in polyhedral oligomeric silsesquioxane (POSS) cage molecules. This is desirable because POSS compounds are useful as intermediate chemical agents that can be further converted or incorporated into a wide variety of chemical feed-stocks useful for the preparation of catalyst supports, monomers, and polymers. The inclusion of POSS molecules imparts new and improved thermal, mechanical, and physical properties to common polymeric materials (i.e., plastics). Some common material property enhancements resulting from the inclusion of POSS are lower density, expanded operational temperature range, and oxidation resistance. Materials created by this process have virtually unlimited application in both the military and commercial sectors. (Dr. T. Haddad, AFRL/PRSM, (661) 275-5761)

NEW FUEL STUDIED BY PR RESEARCHERS: Propulsion Directorate researchers recently concluded an investigation of quadricyclane (C_7H_8), a potential new fuel. Quadricyclane was first produced in significant quantities by Exciton under a PR sponsored SBIR in 2002, and it is presently being considered both as a fuel and as an additive to kerosene rocket fuel (RP-1) to substantially increase the payload capacity of rocket powered vehicles. The study utilized PR's unique Fourier Transform Mass Spectrometer (FTMS) to report on the formation of positive ions

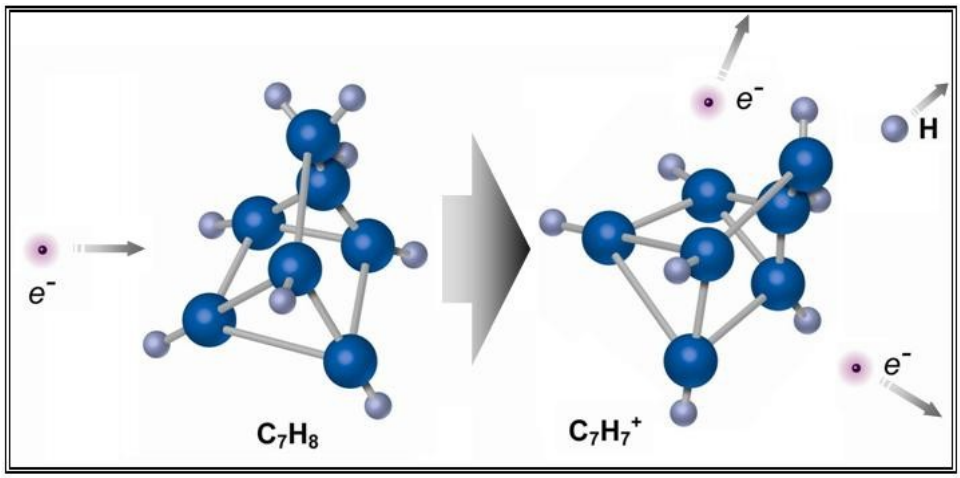


Illustration showing the process of dissociative ionization of quadricyclane (C_7H_8)

[†] Dr. Haddad is an on-site contractor working in the Propulsion Materials Applications Branch (AFRL/PRSM) at Edwards AFB, California.

[‡] Prof. Feher was with the University of California-Irvine at the time the patent was submitted, but he is now with Goodyear.

by electron impact ionization and subsequent ion-molecule reactions. This work makes a significant contribution to the understanding of quadricyclane's ion kinetics, and it may aid other researchers in efficiently utilizing quadricyclane as a next generation fuel. This study was conducted by PR's Drs. Charles DeJoseph, Robert Lee, and Alan Garscadden and Dr. Charles Jiao of Innovative Scientific Solutions, Inc. (ISSI). (Dr. C. DeJoseph, AFRL/PRPE, (937) 255-2923)

Mr. Ted Fecke's promotion to the rank of Senior Leader (SL) was recently approved, and he will now serve as Technical Advisor for Propulsion within ASC/EN

TURBINE ENGINE DIVISION CHIEF ENGINEER PROMOTED TO SENIOR LEADER: The promotion of Mr. Ted Fecke to the rank of Senior Leader (SL) was recently approved by the Secretary of the Air Force, Dr. James G. Roche. With this promotion, Mr. Fecke joins a select group of individuals responsible for ensuring that the Air Force maintains the proper course. Mr. Fecke has been assigned the role of Technical Advisor for Propulsion within Aeronautical System Center's Engineering Directorate (ASC/EN) at Wright-Patterson AFB, Ohio. This is a critical position that advises the AF Propulsion Product Group Manager (PPGM), Mr. Timothy Dues, on the Air Force's inventory of more than 20,000 turbine engines. Mr. Jeff Stricker will be Mr. Fecke's successor as Chief Engineer of the Propulsion Directorate's Turbine Engine Division (AFRL/PRT). (Mr. W. Koop, AFRL/PRT, (937) 255-4100)